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ABSTRACT

This report presents a public workshop by the Committee on Scientific Principles in Education Research, which was held on March 7-8, 2001. The committee was organized into three main sessions: (1) "Supporting Scientific Quality at the Federal Level: Consistency and Variation," which defines scientific quality and how it is supported by research organizations; (2) "The Interface of Research and Practice in Education: Linking Quality and Utility," which focuses on the scientific underpinnings of education research and the use of research in practice; and (3) "Evidence and Inference: Consistency and Variation Revisited," which focuses on the similarities and differences of concepts, evidence, and inference across disciplines. Appendices include the workshop agenda, workshop speaker biosketches, and workshop participants. (YDS)

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Science, Evidence, and Inference in Education

Report of a Workshop

Lisa Towne, Richard J. Shavelson, and Michael J. Feuer, Editors

Committee on Scientific Principles in Education Research
Center for Education
Division of Behavioral and Social Sciences and Education
National Research Council

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We also wish to thank the workshop speakers, whose remarks stimulated a rich and wide-ranging discussion: Michael Agar, Norman Bradburn, Glen Cain, Susan Chipman, Christopher Cross, Larry V. Hedges, Jeremy Kilpatrick, David Klahr, Sharon Lewis, G. Reid Lyon, C. Kent McGuire, Robert Mislevy, William Morrill, William Quinn, Diane Ravitch, Sally Rockey, Steven Ross, Nancy Butler Songer, Judith Sunley, Richard Suzman, Peter Tillers, and Maris Vinovskis. During each session of the workshop, a committee member chaired and skillfully guided the discussions: Donald Barfield, Robert Boruch, Jere Confrey, Robert DeHaan, Paul Holland, and Ellen Condliffe Lagemann. Other committee members, as well as several participants, contributed questions and insights that significantly enhanced the dialogue.

The committee conceived the workshop. Lisa Towne, staff director of the committee, Richard J. Shavelson, committee chair, and Michael J. Feuer, director of the Center for Education, composed this summary.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

J. Myron Atkin, Stanford University
Ellen Guiney, Boston Plan - Boston Annenberg Challenge
Paul Hood, WestEd
David Myers, Mathematica Policy Research, Inc.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Robert Linn of the University of Colorado. Appointed by the National Research Council, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Finally, we wish to thank Kirsten Sampson Snyder for deftly guiding us through this report review process and Yvonne Wise for her helpful editorial suggestions.

Preface

As the demand grows for reliable and credible information to guide policy and practice in the current education reform environment, research on education has again come into the political spotlight. Questions about the nature of evidence have recently spilled over from a relatively contained debate among the education research community into the broader policy and practice arenas. In the federal government, several education initiatives have attempted to codify sentiments for more rigorous research into operational laws and programs.[1] These bills use language such as "scientifically valid," "research-based," and "standards of quality" for research and its application to practice, with various definitions.

Although these legislative trends are relatively new, systematic inquiry into teaching, learning, and schooling in the United States dates back at least to the nineteenth century. This inquiry has generated bodies of scientific knowledge that have profound implications for education. For example, we have seen dramatic advances in understanding how people learn, how young children acquire early reading skills, and how to design and evaluate educational and psychological measurements. However, the highly contextualized nature of education and the wide range of disciplinary perspectives that bear on it have rendered the identification of reducible, generalizable principles—of the sort that typify other scientific disciplines—difficult and slow to achieve. Indeed, a scientific basis for education research has long itself been at issue.

It is in this turbulent context that the U.S. Department of Education's National Educational Research Policy and Priorities Board (NERPPB) has asked the NRC to establish a study committee to consider the scientific underpinnings of research in education. The committee's work is one part of a larger federal effort to improve the utility and quality of education research and is designed to contribute to, and learn from, related initiatives (e.g., RAND study panels in reading and mathematics,[2] NRC Strategic Education Research Program,[3] and the Education Quality Institute[4]). The committee consists of members with expertise in statistics, psychology, sociology, anthropology, philosophy of science, history of education, economics, chemistry, biology, and education practice.

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[1] For example, the Bush administration's *No Child Left Behind* blueprint for the federal role in K-12 education, the Reading Excellence Act, the Comprehensive School Reform Demonstration Act, and a House GOP bill to reauthorize the Office of Educational Research and Improvement.

[2] See www.rand.org/multi/achievementforall

[3] See http://books.nap.edu/books/0309064899/html/

[4] The Education Quality Institute is an emerging independent, nonprofit organization that has been created to provide consumers reliable information on what works to raise student achievement.

Three framing questions summarize the committee's charge:

1. **What are the principles of scientific quality in education research?**

   To address this question, the committee is considering how the purposes, norms of inquiry, methods, and traditions of scientific inquiry translate in the study of education. The committee is considering what scientific quality means, both in individual research projects, as well as in programs of research, to better understand how knowledge can be organized, synthesized, and generalized.

2. **How can research-based knowledge in education cumulate?**

   Closely related to the first question, the committee is focusing on the mechanisms that support the cumulation of knowledge from scientifically based education research—the organization and synthesis of knowledge generated from multiple investigations. The committee is considering the role of the professional research community, the practitioner community, and the federal government.

3. **How can a federal research agency promote and protect scientific quality in the education research it supports?**

   Based on findings about scientific quality in education research and what influences the accumulation of knowledge, the committee will consider design principles necessary for a federal agency to foster the scientific integrity of the work it funds. Among the issues explored by the committee are (a) how internal infrastructure mechanisms, such as peer-review systems, affect research quality, (b) how external forces, such as political influence, affect research quality, and (c) how the federal role can build the capacity of the field to do high-quality work.

The committee sponsored a public workshop on March 7-8, 2001 to engage a broad audience of over 125 participants in dialogue about some of the issues and challenges it faces. To help map the terrain related to its charge, the committee organized the event into three main sessions:

1. Supporting Scientific Quality at the Federal Level,
2. The Interface of Research and Practice in Education, and
3. Evidence and Inference.

The first session—Supporting Scientific Quality at the Federal Level—was designed to help the committee understand ways in which a range of research agencies conceive and support scientific rigor and integrity (see framing question #3). Specifically, panelists were asked to consider the following questions:

A. How do research organizations define scientific quality for both individual projects and programs or portfolios of work? How did these definitions develop and from where were they derived?
B. What are the enabling conditions that allow research organizations to promote and sustain scientific quality in the projects and programs they support over time?
C. What impediments have hindered quality and how have they been addressed?

The second session—The Interface of Research and Practice in Education—was designed to help the committee understand the relationship between its focus on the scientific underpinnings of education research and the use of research in practice. This topic, and thus the workshop session, relates to two of the three framing questions for the committee's work. The committee wanted to consider the possible trade-offs involved in simultaneously maximizing the utility of the research and scientific rigor (see framing question #1). The committee was also interested in whether and how bodies of knowledge that have accumulated from scientific research inform practice (see framing question #2).

To organize this session, the committee developed two roundtable discussions focused on: (1) the relationship between research and education reform and (2) the relationship between scientific quality and the utility of research. To address the relationship between research and reform, roundtable discussants were first asked to consider:

A. What is the nature, quantity, and quality of scientific evidence needed to act, scale up?
B. In what ways can research provide guidance about various decisions in education policy and practice? What are its limitations?
C. In what ways can research provide insights about alternative ways to solve problems? What are its limitations?

To address the relationship between scientific quality and research use, the committee asked the same discussants to consider a second set of questions:

A. Does "quality" mean the same thing to researchers as it does to the users of research? Should it?
B. What are the characteristics of research that influence education decision making, and what are the conditions under which it can drive change?
C. Are there trade-offs required in achieving researchers' standards of quality and consumers' standards for utility?

Finally, to help the committee articulate scientific principles in education research (see framing question #1), a third session was designed to elucidate similarities and differences in the core concepts of evidence and inference across a range of disciplines and fields.

This document summarizes the workshop, and is organized around main session themes. Appendixes include the full agenda of the event (Appendix A), biosketches of workshop speakers (Appendix B), and a list of workshop participants (Appendix C). The verbatim transcript, in text and audio formats, can be found on CFE's webpage at: http://www4.nas.edu/cfe/cfe.nsf/web/other_projects?OpenDocument (under "Scientific Principles in Educational Research: Explorations and Perspectives for OERI").

The committee's intent in issuing this summary is to communicate to an even wider audience the key themes that emerged from the workshop discussions. We hope that this report contributes to ongoing deliberations and discussions about the role of research in generating new knowledge and in informing education decision making, as well as informs policy makers considering reauthorization of the Office of Educational Research and Improvement (OERI).

AN IMPORTANT CAVEAT

We want to clarify that this report is not intended to reflect the consensus of the committee on findings, conclusions, and recommendations from its study. That consensus is evolving and will be articulated in the committee's final report, which is due in fall 2001.

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Theme 1. Supporting Scientific Quality at the Federal Level: Consistency and Variation

To help the committee consider "design principles" that support science in a federal education research agency, the first workshop session was designed to engage a select set of experienced federal research managers in a discussion of how their institutions define and support scientifically based research. Panelists represented agencies that support a range of sciences—primarily social and behavioral—with an emphasis on institutions that fund the lion's share of federally sponsored research in education: the Office of Educational Research and Improvement (OERI), the National Science Foundation (NSF), and the National Institute for Child Health and Human Development (NICHD).

WHAT IS QUALITY? CONSENSUS ON BASIC PRINCIPLES, DIVERGENCE ON SPECIFICS

Across agencies and disciplines, panelists agreed that research quality at a conceptual level consisted of "rigor, vigor, and vision." How these broad concepts translated into specific standards of quality varied; no single definition of quality emerged. One NSF panelist offered some specific elements of quality that the Education and Human Resources Directorate looks for in evaluating research proposals: for example, a conceptually deep, internally consistent plan; evidence that it stretches the boundaries of what is known; clarity about connections to prior research and related disciplines; and its relevance to practice. Another Office of Naval Research panelist dismissed the question altogether, asserting bluntly that true scientists do not need definitions to conduct high-quality research. In a later session, this sentiment was reinforced by a guest speaker who suggested he did not think it would be difficult to define research quality "standards."

> *Real scientists just do it. They don't brood about whether what they are doing counts as science.*
> —**Susan Chipman**

> *It's a lot easier to think about... quality if you can be very explicit and clear about the things you are trying to do... it at least gives you a context [to understand] evidence, and methods, and use.*
> —**Kent McGuire**

Some panelists suggested that certain principles of quality apply to all sciences, including scientific research in education. In contrast, another panelist emphasized the apparent absence of a well-accepted definition of quality held by those conducting research on education. He argued "quality is an elusive concept...very much in the eye of the beholder..."

Sometimes the small steps add up and sometimes they don't. And sometimes you don't know that for ten to twenty years. It's very difficult to judge...
—**Richard Suzman**

The definition of quality also varies according to which aspect of the research enterprise is considered. Panelists discussed quality with respect to research proposals, research output or results, research use, and research programs. For example, one panelist distinguished between quality in projects and programs, while another reinforced this distinction by arguing that even when most individual projects in a program of work are good, there can still be a lack of coherence in the program as a whole.

The accumulation of knowledge is a primary goal of sustained research efforts in all the agencies represented at the workshop. Panelists argued that gauging quality against this goal was more difficult than assessing individual proposals or reports. One National Institutes of Health (NIH) speaker suggested that all projects added to the cumulativity of knowledge, but that the key question was which ones contribute major findings and breakthroughs. He went on to say that it is very difficult to judge if individual findings added up to something greater, and that this accumulation often takes decades.

In a University of Chicago Medical School post-doctoral program in research...I was astounded...because applicants wanted to learn evidence-based medicine. I said...'what are you practicing?' And [they] said 'we basically do what our chief has been doing for the last 20 years...'
—**Norman Bradburn**

Raising issues that would be central in a later workshop session, some panelists specifically referenced quality from the perspective of the application of the research in practice. As one Department of Agriculture panelist noted, the struggle is "how best to get information out to the consumers." Another panelist argued for a balance between scientific rigor and practical utility.

THE PURSUIT OF QUALITY: NO ONE MODEL

Quality is supported in federal research agencies through a range of mechanisms. While some common strategies emerged, it was clear that no one model is envisioned as ideal. One panelist, however, singled out this diversity as a **positive** aspect of the federal research enterprise and argued that it is a strength of the U.S. system that we have so many different processes, a result of which is a greater likelihood of good projects being funded.

It's nonsense to think everybody knows good science even if they are from out of field. They don't. [We need people who can] consider multiple perspectives but always have quality in mind.
—**Reid Lyon**

Amid this variability, peer review emerged as the most common and most trusted mechanism federal agencies use to promote quality in the research they fund. However, it is not universally used, and the goals, structure, and composition of peer-review panels vary substantially from agency to agency. Two speakers explained that peer review is both a screen and a feedback mechanism: even applicants whose proposals are rejected receive important feedback that strengthens their work and improves their future projects.

Many panelists emphasized the importance of selecting peer reviewers and matching expertise and perspectives to the proposals being evaluated. One NIH speaker was especially strong in his insistence on using reviewers who were widely recognized experts in the field, and he warned against the mistaken belief "everybody knows good science."

> *We don't honor the sacred cow of peer review...we do like to consider ourselves peers. We are held accountable in terms of being able to tell a reasonable story about how what we are funding adds to something within 30 years...*
> —**Susan Chipman**

At the Office of Naval Research, peer review is not the screening mechanism of choice, but agency staff have more discretion in selecting proposals. While the other panelists heavily relied on peer review, they also agreed that it had its limitations, and that alone could not ensure that an agency would always generate good work. One panelist summarized the discussion by noting the difficulty in attributing an agency's successes and failures to a single factor such as peer review.

Indeed, the research managers noted several other strategies for bolstering the quality of the work they support. For example, most panelists targeted their resources to fund centers that engaged scientists from a range of disciplines to focus on solving clearly defined problems. Another common way in which panelists support quality is through a sustained interaction with both the research community and the communities (stakeholders) that the research is intended to inform. These communications serve a number of goals in research agencies, including the identification of researchable problems and substantive gaps in knowledge.

ENABLING CONDITIONS: AN ENVIRONMENT SUPPORTING RESEARCH QUALITY

What are the conditions under which quality is best supported? Panelists offered a range of responses, with a fair amount of consensus on some key requirements: flexibility and autonomy, quality staff, and sustained efforts requiring a critical mass of resources.

The flexibility and autonomy of research agencies was cited as a necessary condition to be an effective institution. The ability to make quick decisions, shift resources toward particularly promising opportunities, and maintain a supple approach to proposals and projects were cited as key determinants of quality.

> *I have it easier [than OERI and NSF because] I work for an organization that can literally turn on a dime. We [NIH] can make rapid decisions ...[when] scientific opportunity arises. We are not encumbered... by the amount of regulation that OERI is. ...OERI should never be held to a quality standard until [regulations] are out of there.*
> —**Reid Lyon**

Many panelists cited the importance of recruiting and retaining a high-quality staff who could think across domains and methodologies. The staff characteristics that were identified as most critical were similar to those of effective peer reviewers: respected and agile thinkers.

The first contract in artificially intelligent tutoring was awarded in 1969...today we are just beginning to see the first practical applications ... it takes a long term investment.
—**Susan Chipman**

The importance of a sustained research effort on important short-, mid-, and long-term problems or possibilities was emphasized repeatedly. For example, at the Office of Naval Research, research on advanced educational technology took 30 years to yield applicable products; similarly, a reading program at the NIH started with three centers and gradually grew to a 42-site research network that has substantially improved our understanding of how children learn to read.

OBSTACLES TO THE PURSUIT OF QUALITY

Mirroring and reinforcing the earlier discussion of flexibility as an enabling condition for supporting quality, panelists repeatedly cited a lack of flexibility and autonomy as an obstacle. Two panelists specifically derided the prescriptive nature of OERI's authorizing statute, arguing that it stripped agency leadership from making necessary professional judgments about scientific opportunity. This issue repeatedly resurfaced throughout the session. Other participants cited the abundance of service-oriented programs that OERI administers as a hindrance to research quality.

Another problem with the research agenda [at OERI] is ...a disparate assorted bunch of reform activities... None of these...activities was based on research. Their negative evaluations have absolutely no impact on their continuing to be in place.
—**Diane Ravitch**

Another common obstacle—particularly in education research—mentioned by panelists was the lack of resources to conduct sustained, high-quality work. One panelist estimated that as a nation we invest just two-tenths of one percent of the total amount spent on K-12 education each year in research and development, compared to roughly 5 to 10 percent in other areas. The lack of, and need for, a "critical mass" of resources also came up in a later discussion of education research and practice. Just as panelists in this first session argued that resources were insufficient at the federal level, so too was the proportion of dollars spent on research and evaluation at the local level.

If a school district gets $100,000... they spend 2% on formative evaluation and research. We way underfund research. We don't find out what works... [then] not only can we not improve them [the programs] but they don't last...as soon as the next [leadership] group comes in, [it is abandoned because the programs] haven't grown roots that can withstand an administrative change...
—**Steven Ross**

Another problem commonly cited by the panelists is a lack of candor and accountability. One panelist, arguing that the lack of accountability and candor with sponsors is an essential element of an effective federal research organization, suggested that researchers "are too keen on making promissory notes in the political system in order to get resources" when they cannot possibly deliver on those promises. This lack of candor, panelists suggested, contributes to unrealistic expectations—among researchers, practitioners and policy makers—about how quickly rigorous research can be conducted, as well as how quickly the results of research can "go to scale" in practice.

On the issue of accountability, two panelists argued that the incentive structures for improving quality in education research are lacking, citing strong pressure from lobbyists to fund established institutions regardless of the quality of their work. This sentiment was echoed by a panelist from the field of health, who suggested that it was very difficult to identify and reduce funding for areas of research that are not fruitful if that research is performed or is backed by politically influential groups.

> *...where there hasn't been much [research] progress, there is a tremendous reluctance to state that clearly...to diagnose it...and then look why it hasn't happened...*
> —**Richard Suzman**

Panelists across such diverse fields as health, agriculture, and education cited a lack of consensus on goals as an impediment to promoting and sustaining quality. They argued that this absence of agreement on how to define and measure success results in fragmented research and an inability to sustain programs that can grow knowledge in a specific area.

Finally, several panelists argued that political interference, often in the form of congressional earmarks, detracts from the development of sustained programs of research that can accumulate research-based knowledge over time.

> *I found that there was almost no discretion in the [OERI] budget because everything was either allocated to a specific entity or earmarked...*
> —**Diane Ravitch**

REVITALIZING FEDERAL EDUCATION RESEARCH AND DEVELOPMENT: IMPROVING THE R&D CENTERS, REGIONAL EDUCATIONAL LABORATORIES, AND THE 'NEW' OERI

The workshop session on federal research agencies concluded with a luncheon discussion of a forthcoming book[5] on the history of OERI. Maris Vinovskis, the book's author, presented a brief overview of the major findings of the book. The book features an evaluation of past OERI R&D Centers and Regional Laboratories.

> *My fear is that [policymakers working on OERI reauthorization] will prescribe a whole series of activities that don't make sense...but they are grappling out of frustration...they don't trust you and me [education researchers] to do the high quality work.*
> —**Maris Vinovskis**

Vinovskis discussed the significant variation he found in the quality of the work conducted by the Centers and Labs. Related, he noted that a lack of coherence typified several of the institutions he evaluated even though several of their individual projects were excellent. He also described in detail the impact of Congress and lobbying groups on the politicization of education research. Echoing themes that emerged from earlier panels, Vinovskis repeatedly called for more candor and accountability, arguing that the academic community has been unwilling to engage in a dialogue of the criticisms he has made about the agency. He also agreed that funding for education research was inadequate.

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[5] Vinovskis, M. (In press). *Revitalizing Federal Education Research and Development: Improving the R&D Centers, Regional Educational Laboratories, and the 'New' OERI.* Ann Arbor: University of Michigan Press.

In a lively discussion spurred by Vinovskis's presentation, participants raised a number of detailed questions about how he assessed the centers and labs he describes in his book. Following on Vinovskis' observation that many of the programs he assessed lacked coherence, participants also discussed the disincentives that prevent collaborative work and some ways those disincentives can be overcome. During the discussion, Vinovskis and members of the audience also engaged in a heated debate about the merits of various funding and staffing decisions made by OERI leadership.

Theme 2. The Interface of Research and Practice in Education: Linking Quality and Utility

Does quality research lead to its effective use in education policy and practice, and if so, how? What role does high-quality research play in education improvement? These questions, implicitly embedded in the charge to the committee, provided the frame for the second session of the workshop. This session featured a roundtable discussion on the interface of research and practice in education, with a focus on the relationship between research quality and research use. Six invited discussants with perspectives on education research, education practice, and their connections, engaged in a dialogue that ranged from the appropriate role of evidence in education reform to how to broker better communications between researchers and practitioners.

EVIDENCE IN AN ERA OF ACCOUNTABILITY

> *We will see things scale up, because we are going to be driven by performance...[in ways] we have never seen before. Educators have never asked much of education research and development, and that's exactly what we gave them...that's not true anymore.*
> —**Paul Hood**

Roundtable discussants agreed that research can be a powerful force for improving policy and practice in education. Several discussants linked research-based knowledge to the accountability structures of standards-based reform efforts, arguing that the emphasis on performance in the K-12 education system was fueling a rising demand for evidence on the effectiveness of various strategies for improving student achievement. One participant flatly stated that educators had never asked much of education research, and "that's exactly what we [the research community] gave them." In this new era of accountability, he asserted, that dynamic is changing.

THE ROLE OF RESEARCH IN REFORM: POWERFUL YET MISUNDERSTOOD

Discussants agreed that oversimplified expectations about the role of research in reform efforts undermined its potential impact. Specifically, several discussants rejected the common metaphor of "translating research into practice," arguing that even the highest quality research cannot provide simple answers to the complex problems of teaching and learning. One discussant asserted that the power of research lies in its potential to foster a public dialogue of how to improve education. He elaborated, arguing that engaging the

> *[The] assumption that quality research will lead to agreement... is not true in any science... we have...a romantic notion that researchers [can] tell teachers what to do in a given situation, when the situation is very complex.*
> —**Denis Phillips**

public in this way would promote the democratic ideal of an educated citizenry and significantly enhance the capacity of all actors in the system to improve education.

A number of speakers underscored this problem by describing instances in which partnerships between researchers and schools broke down when quick improvements in student outcomes were not achieved. Related, a participant asked if education research was ready to respond to new (federal) requirements that schools adopt "research-based" programs. Discussants agreed that generally the answer is no.

BRIDGING THE GULF BETWEEN EDUCATION RESEARCH AND PRACTICE: QUALITY, CULTURE, AND INCENTIVES

Do education researchers and the potential users of research view quality in the same way? Discussants basically agreed that while both communities value quality, the relative emphasis on various aspects of quality differs. Participants offered examples that illustrated the contrast: in simple terms, researchers cherish scientific controls and generalizations about effects; practitioners value adaptation and richly contextualized information about implementation. One discussant argued that striking the right balance was essential. Another participant directly related the concepts of research quality and research utility by asserting that the more likely it is that research results will be implemented in practice, the more incumbent it is for the researcher to adhere to standards of rigor in the research process.

> *Researchers are trained to do research, and educators are trained to educate children. The goals are different but there needs to be give and take... the quality issue still has to be there.*
> —**Sharon Lewis**

Agreeing that striking the right balance is a difficult task, a strong theme in this discussion related to the incentive systems and attendant cultures of researchers and educators. These differences were described as major impediments to forging the connections necessary to enable collaborations between the two.

> *I [an evaluator] often have the experience... of being surprised by my [school-based] clients when they interpret back to me what it is I told them. And for the first time, I understand something I never understood before...this experience of working back and forth is at least humbling if not illuminating.*
> —**William Quinn**

Discussants pointed to problems in the way researchers are trained and the incentives inherent to university tenure and promotion. One discussant suggested that quality could mean the same thing to researchers and practitioners if researchers had practitioners' interests in mind. Others agreed; for example, one discussant who conducts evaluations for schools suggested that quality and utility are both aspects of the overall value of research and that good evaluators need to "ensure the scientific integrity of the research while attending to its applicability in practice."

Another discussant pointed to the pressure and incentives faced by researchers to publish in peer-reviewed journals, contrasting this situation with many physicians' practical incentives to cure patients. Participants offered two examples of effective strategies for conducting inquiry in applied education settings that are not typically valued by universities: (1) brokering sustainable partnerships with schools, and (2) engaging in jointly authored work of interdisciplinary teams of researchers. When university-based researchers try to conduct this kind of work, one discussant argued, "the incentive to do innovative work goes down." She also suggested the requirements for tenure and promotion at most universities pose dilemmas for junior faculty who find it difficult "to articulate the value of what they are doing."

Despite these difficulties, participants suggested that the research effort can be greatly enriched by engaging in this interface. Reflecting on his career conducting evaluations with schools, one discussant told the group that he consistently learns something new from interacting with his clients who have rich contextual understandings of their situations.

Another major thread of this discussion focused on teacher professional development. Participants pointed to preservice teacher education, arguing that schools of education should train prospective teachers to understand research and evaluation, and to be savvy consumers. There was some disagreement if this meant adding a research methods course to the curriculum of education students. Drawing a parallel to medicine, one discussant dismissed that strategy, arguing that medical research is adopted in practice not because physicians understand or investigate its methods, but because the mechanism inherent in the research makes sense to them. He further suggested that physicians assume that the profession takes care of the proper use of methodology. Following on the medical example, another participant suggested that research will never be meaningfully connected to practice without the emergence of an intermediate field—like those in engineering and medicine—to fill the gap at the nexus.

> *We need to create a much better interface... between educational research...and practice... we're simply going to have to have people in that intermediate... You find them in medicine. You find them in engineering...no matter how high the quality of the research, if you don't have people in...the intermediate position...you simply can't make the powerful... connections that you would hope to have.*
> —**Paul Hood**

WANTED: OBJECTIVE SYNTHESES OF RESEARCH FINDINGS

Discussants agreed that objective, synthesizing mechanisms that can reconcile disparate findings and reach consensus on what is known in a particular area are critical for both researchers and practitioners. Participants suggested that this need was particularly acute for educators and policy makers who commonly face inconclusive—and sometimes contradictory—evidence when they seek guidance from research. Discussants agreed it is difficult to answer simple questions like "what works?" because the highly diverse character of education by its very nature generates uneven answers. One panelist identified the lack of a common resource for education professionals—like Medline for physicians and Lexis-Nexis for attorneys—as problematic.

> *Where do [teachers] then go when they enter into the profession to find out what works? In law or medicine, they have avenues to look to: Medline, MEDLARS, Lexis-Nexis.... I would submit that ERIC [Educational Resources Information Center] does not do that and there is nothing right now that's comparable.*
> —**Christopher Cross**

In his work advising school districts about the effectiveness of various comprehensive school reform models, for example, one discussant said for every evaluation he has seen, there is always one school where a model "worked"—even though on average it does not. He went on to say an objective "voice" was needed to help practitioners understand the conditions under which certain strategies seem to work, at least sometimes, and what strategies do not seem to work at all. The new Education Quality Institute was cited as an organization that could provide such a voice. The availability of evidence to support most claims and the lack of an authority to make summary judgments about a body of evidence was described as particularly problematic because it enables vendors to create "beautiful bar graphs that show their programs work."

Participants argued that the lack of a synthesis mechanism makes it difficult to encourage administrators and policy makers to use evidence as well. They agreed that policy decisions made by superintendents, state aides, and federal policy makers are driven by the power of anecdote. Participants suggested that the case for systematic evidence could be made stronger by harnessing the power of a story to illustrate broad conjectures.

One discussant suggested that synthesis work was an essential exercise for the research community as well. He argued that research-based knowledge progresses when peers are forced to confront one another about their beliefs and preferences to advance consensus.

Theme 3. Evidence and Inference: Consistency and Variation Revisited

At the core of science is a commitment to rigorous reasoning, method, and the use of evidence. The final session of the workshop was designed to take a step back from the specific issues of how federal agencies support science and how science can inform education practice, and to focus on the "first principles" of evidentiary and inferential reasoning. To help it deliberate about the scientific principles of education research, the committee assembled a panel of scholars from a range of scientific disciplines and professions who provided their perspectives on the ways evidence and inference are used in their fields. Panelists brought expertise from education assessment, linguistic anthropology, labor economics, law, and the emerging interdisciplinary field of systematic synthesis.

> *Evidence is almost always incomplete, inconclusive, and amenable to multiple explanations…we always reason in the presence of uncertainty.*
> —**Robert Mislevy**

The panel began with a talk by an expert in education assessment, whose scholarly work has focused on the identification of "first principles" of evidentiary inference and reasoning. His presentation served as a frame for subsequent presentations and discussions.[6] In his introductory remarks, he stressed the difference between data and evidence: "Datum becomes evidence in some analytic problem when its relevance to conjectures being considered is established." Any piece of evidence, he argued, is almost always "incomplete, inconclusive, and amenable to multiple explanations." He also said that using evidence to make inferences—explanations, conclusions, or predictions based on what we know and observe—is always done in the presence of uncertainty.

The panel discussion following illustrated the same theme of consistency and variation that surfaced in previous sessions. Despite dramatic variability with respect to the goals, methods, and products of the exercise, a consensus among the panelists on the basic tenets of reasoning about evidence began to develop.

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[6] His presentation and the some of the quotes provided here first appeared in: Schum, D.A. (1994). *The Evidential Foundations of Probabilistic Reasoning*. New York: Wiley.

BACK TO BASICS: EXPLICIT REASONING, RIGOROUS METHOD, PUBLIC PROCESS

> *A crucial aspect of systematic syntheses is that they need to make public, and therefore open to scientific scrutiny, the methods of the synthesis process…a commitment to revising reviews periodically is a good model for how the accumulation of evidence can work…*
> **—Larry Hedges**

Each panelist described at least three common characteristics of effective inferential reasoning: (1) a visible and explicit form of argument with a clear delineation of constructs, frameworks and theories (explicit reasoning); (2) the identification and explanation of patterns, variations, and rival hypotheses (rigorous method); and (3) a commitment to clear and accessible documentation of how inferences are made (public process).

Panelists described the rigors of reasoning about evidence. Although accomplished by different means (e.g., abduction, induction, and deduction), "inferential force"—as it was described by one panelist—is created by moving among the data, explaining the warrants for each step in the inferential chain, and adding appropriate qualifiers and conditions. Inferences are strengthened by subsequently and iteratively making predictions and testing them, seeking the best explanation by considering and eliminating alternative or rival hypotheses, describing possible unseen mechanisms, and revising frameworks to account for unexpected data or results.

Several panelists emphasized the importance of making the inferential process publicly available to encourage scrutiny by the professional community. Subjecting claims to criticism and engaging in a debate about the warrants for knowledge was explicitly identified by several panelists as an indication of the health of the knowledge-generating enterprise.

> *Controlled experiments are challenged by the replicability criterion: Does the experiment match the practice…that would be in operation if the programs were to be adopted? They also are associated with high costs and there may be,ethical constraints. Uncontrolled experiments (observational studies) face selection bias. Avoiding this bias…is always difficult.*
> **—Glen Cain**

THE SPECIALIZATION OF INFERENTIAL REASONING: VARIATION IN GOALS, METHODS, AND PRODUCTS

Although each of the panelists made clear the importance of rigorous thinking in making inferences and claims, the variability in the ways in which different fields and disciplines treat evidence and inference was also apparent. The legal scholar on the panel made this point explicitly, arguing "the coherence and elegance of a particular perspective on inference should not be mistaken for the omnipotence of any such perspective" and the inferential reasoning process will always involve "a wide array of conceptual and perceptual processes."

The panel presentations and subsequent discussions illustrated this inherent specialization in evidentiary and inferential reasoning. Specifically, the goal of the inference and its intended product gave rise to much of the variability in the method of the reasoning

process across fields. Contrasting ethnographic techniques with traditional social science methods, for example, one panelist, a linguistic anthropologist, identified the difference in the objective of each type of research explicitly: "The goal [of ethnography] is to understand how things connect rather than how to isolate a measure." The end product, therefore, is also different: "[Ethnography] is theory-generating rather than theory-testing."

> *[In the traditional sciences], if you end up with a concept you didn't have before you started, your career is over... In my field [ethnography], if you* don't *end up with a new concept that you didn't have before you started, your career is over.*
> —**Michael Agar** (emphasis added)

The labor economist on the panel traced the evolution of econometric methods that model the relationship between inputs and outputs. He commented on the now well-known tension between controlled experiments and observational studies, identifying the relative strengths and weaknesses of each strategy.

Legal practice and scholarship blend a variety of inferential techniques. Since law is not concerned with identifying fundamental principles, the legal scholar on the panel suggested that there are limits to the parallels that can be drawn between inference in law and inference in science. He did, however, suggest one way in which scientists might learn from lawyers, judges, and legal scholars from the adversarial system of American justice, reminding the scientists these actors are "good at identifying multiple sources of uncertainty."

> *Often you find that study findings may contradict one another in terms of statistical significance, the sign of the effect, or the magnitude of the effect... these conditions are not unique to education, and in fact cover a wide swath of the sciences... experimental ecology, some fields of chemistry, medicine, psychology, and public health...*
> —**Larry Hedges**

Another panelist described the problem of inference in systematic syntheses. This interdisciplinary field, he explained, enables comparisons across studies to produce summary descriptions of **bodies** of research evidence. He noted that the problems of drawing inferences from multiple studies are the same across disciplines and similar to those of drawing inferences in individual studies.

Synthesis and Next Steps for the Committee

What does it all mean? A final luncheon session was designed to help the committee synthesize what they heard and to raise questions and issues the committee should address in conducting further work. Commentary from two rapporteurs who attended each of the workshop sessions concluded the event.

MAXIMIZING RESEARCH QUALITY AND UTILITY

Research quality and utility were highlighted again as distinct concepts with independent properties, both of which are important to maximize. On a similar issue, however, one rapporteur cautioned against limiting research dollars to areas that seem most likely to have immediate impact on practice. He suggested that this lens would severely limit the potential of research to improve incrementally our understanding of the underlying processes of teaching, learning, and schooling.

THE NATURE AND PROGRESSION OF SCIENCE

Picking up on a discussion from the first workshop session, a rapporteur challenged the basis of the criticism that research in education has a high "waste tolerance." Reflecting on the nature of science as an iterative, non-linear, process of knowledge accumulation, he argued that a view of unproductive paths as "waste" was the wrong model. Trying things out in the face of uncertainty is a natural part of the scientific process. To illustrate the point that reasoning always takes place amid uncertainty, the rapporteur used a business analogy. He argued that the quality of an investment decision depends on how well the investor reasoned with the information he or she had at the time. The eventual outcome of that decision—financial loss or gain—is irrelevant to any consideration of whether the decision was a sound one at the time it was made.

> *If in hindsight you look at an investment decision that went belly up, whether that decision was good or bad depends on whether or not based on what you knew at the time you should have known better…if not, you had to try it out to find out what would happen… it all depends on if you reasoned well in the context of that decision.*
> —**David Klahr**

THE BARRIERS TO LINKING RESEARCH AND REFORM: IS QUALITY ONE OF THEM?

Commenting that education practice seems impervious to well-established bodies of research in cognition, learning, and memory, a rapporteur posed the question if we fully understand the reasons why education is reluctant to change in the face of such evidence. He suggested that more research about the diffusion of innovation in school settings was needed to better understand the role of quality in research use.

MODELING COMPLEXITY: JUST TRY THINGS OUT

> *...when we want to find out if a car will survive a crash, we don't do simultaneous differential equations, we drive a car into a wall...when things get complex, we just try things out...education shouldn't feel so bad about where it is...*
> —**David Klahr**

Reflecting on a workshop participant's suggestion that some new "instructional engineering" career may need to be invented to bridge research and practice in education, a rapporteur provided an example from physics to illustrate the point. Although the laws of motion are well understood and well documented, when automotive engineers want to determine whether one car is more crashworthy than another, they don't "solve simultaneous differential equations." Instead, they drive each car into a wall and examine the wreckage. While this may seem to be an expensive way to do a comparison, when things get complex—even in the "hard sciences"—the only way to find out what will happen is to find out what happens. He went on to say that when educators take this approach, they are often unfairly faulted for being unscientific.

CLARITY ON TERMINOLOGY

Both rapporteurs urged that the committee make clear the important distinctions among the various genres of research in education while deliberating about quality. They argued that terms like research, intervention, evaluation, and clinical need to be articulated and elucidated. In particular, a rapporteur further asserted, the committee should distinguish between science as an act of inquiry and science as an act of design. There is obvious overlap, but one emphasizes understanding of underlying phenomena while the other is more focused on problem-solving.

NEXT STEPS

The workshop served as an information collection exercise for the committee. The next phase of the committee's work involves intensively deliberating and writing to set forth the committee's response to its three framing questions (see preface), to forge the consensus of the group, and to articulate that consensus in a report of its findings. The committee expects to release its consensus report in fall 2001.

APPENDIX A: WORKSHOP AGENDA

THE NATIONAL ACADEMIES
CENTER FOR EDUCATION
Committee on Scientific Principles in Education Research

Science, Evidence, and Inference in Education:
A Workshop

AGENDA

WEDNESDAY, MARCH 7
National Academy of Sciences Building
21st & C Streets, NW
The Lecture Room

7:30 am **Continental Breakfast**

8:00 am **Welcome and Goals for Workshop**
Richard Shavelson, Stanford University and
Chair, Committee on Scientific Principles in Education Research
Michael Feuer, Center for Education, National Research Council

MORNING SESSION:
SUPPORTING SCIENTIFIC QUALITY AT THE FEDERAL LEVEL

8:45 am **Panel #1**
How Scientific Quality Is Conceived and Supported: Perspectives of Federal Research Managers Outside Education

Framing Questions:

- How do research organizations define scientific quality for both individual projects and programs or portfolios of work? How did these definitions develop and from where were they derived?
- What are the enabling conditions that allow research organizations to promote and sustain scientific quality in the projects and programs they support over time?
- What impediments have hindered quality and how have they been addressed?

Chair:
Robert DeHaan, Emory University

Panelists:
Norman Bradburn, NSF Social, Behavioral and Economic Sciences Directorate
Susan Chipman, U.S. Office of Naval Research
Sally Rockey, USDA Cooperative State Research, Education, and Extension Service
Richard Suzman, NIH National Institute on Aging

Discussant:
William Morrill, Caliber Associates

Q&A:
Committee and Audience

10:30 am **Break**

10:45 am **Panel #2**
How Scientific Quality is Conceived and Supported: Perspectives of Federal Research Managers Inside Education

Framing Questions:
- Same as Panel #1

Chair:
Paul Holland, Educational Testing Service

Panelists:
C. Kent McGuire, Manpower Demonstration Research Corporation
G. Reid Lyon, NIH National Institute of Child Health and Human Development
Judith Sunley, NSF Directorate for Education and Human Resources

Discussant:
Diane Ravitch, New York University and Brookings Institution

Q&A:
Committee and Audience

12:30 pm **Luncheon Discussion**
Revitalizing Federal Education Research and Development: Improving the R&D Centers, Regional Educational Laboratories, and the 'New' OERI

Background:
- Vinovskis, Maris, A. "The Federal Role in Educational Research and Development." *Brookings Papers on Education Policy: 2000.*

Chair:
Ellen Condliffe Lagemann, Spencer Foundation

Speaker:
Maris Vinovskis, University of Michigan

Q&A:
Committee and Audience

AFTERNOON SESSION:
THE INTERFACE OF RESEARCH & PRACTICE

2:00 pm **Roundtable Discussion #1**
Research & Reform: The Role of Research in Improving Educational Practice

Framing Questions:

- What is the nature, quantity, and quality of scientific evidence needed to act, scale up?
- In what ways can research provide guidance about various decisions in education policy and practice? What are its limitations?
- In what ways can research provide insights about alternative ways to solve problems? What are its limitations?

Chair:
Jere Confrey, University of Texas

Participants:
Christopher T. Cross, Council for Basic Education
Jeremy Kilpatrick, University of Georgia
Sharon Lewis, Council of Great City Schools
William Quinn, North Central Regional Educational Laboratory
Steven Ross, University of Memphis
Nancy Songer, University of Michigan

Q&A:
Committee and Audience

3:30 pm **Break**

3:45 pm **Roundtable Discussion #2**
Quality & Utility: The Interaction of Research Quality and the Needs of Education Decision-Makers

Framing Questions:

- Does "quality" mean the same thing to researchers as it does to the users of research? Should it?
- What are the characteristics of research that do influence education decision making, and what are the conditions under which it can drive change?
- Are there trade-offs required in achieving researchers' standards of quality and consumers' standards for utility?

Chair:
Donald Barfield, WestEd

Participants:
Same as Roundtable Discussion #1

Q&A:
Committee and Audience

5:00 pm **End Open Session**

THURSDAY, MARCH 8
Holiday Inn Georgetown
2101 Wisconsin Avenue, NW
Mirage I

8:00 am **Continental Breakfast**

8:30 am **Panel #3**
Scientific Evidence and Inference: Disciplinary Perspectives

Frame:
- Robert Mislevy. "Basic Concepts of Evidentiary Reasoning"

Chair:
Robert Boruch, University of Pennsylvania

Panelists:
Michael Agar, University of Maryland
Glen Cain, University of Wisconsin
Larry V. Hedges, University of Chicago
Robert Mislevy, University of Maryland
Peter Tillers, Cardozo Law School, Yeshiva University, Yale Law School

Q&A:
Committee and Audience

10:30 am **Break**

10:45 am **Panel #3 Continued**

12:00 noon **Luncheon Discussion**
Review and Summary: Reflections on What We Have Learned

Chair:
Richard Shavelson, Stanford University

Rapporteurs:
Michael Feuer, National Research Council
David Klahr, Carnegie Mellon University

1:30 pm **End Open Session**

APPENDIX B: WORKSHOP SPEAKER BIOSKETCHES

Michael Agar received his Ph.D. in linguistic anthropology from the Language-Behavior Research Laboratory at the University of California, Berkeley. An NIH Career Award recipient, he is now professor emeritus at the University of Maryland, College Park, with adjunct appointments in Speech Communication and Comparative Literature, as well as at the International Institute for Qualitative Research at the University of Alberta. He works independently with Ethknoworks in Takoma Park, Maryland. Ethknoworks focuses on issues of language, culture, communication and ethnographic research, with applications in fields as diverse as business, public health, conflict resolution, museums, and second language instruction. His past appointments include research positions with public health agencies as well as university positions at the Universities of Hawaii, Houston, and California in the United States, and visits with the Universities of Mysore in India, Surrey in the United Kingdom, and Vienna and the Johannes Kepler University in Austria. His publications include articles in journals from the fields of anthropology, linguistics, folklore and oral history, sociology, psychology, psychiatry, public policy, artificial intelligence, intercultural communication, and the substance use and transportation fields. He also writes for general magazines like *The Smithsonian*. Among his books are *Ripping and Running*, *The Professional Stranger*, *Angel Dust*, *Speaking of Ethnography*, *Independents Declared*, and *Language Shock: Understanding the Culture of Conversation*.

Norman M. Bradburn was appointed Assistant Director of the Social, Behavioral, and Economic Sciences Directorate at the National Science Foundation on March 13, 2000. He is the former Senior Vice President for Research and Director of the National Opinion Research Center, was the Tiffany and Margaret Blake Distinguished Service Professor at the University of Chicago and was a member of the Department of Psychology and also the Harris Graduate School of Public Policy Studies. He served as Provost of the University of Chicago from 1984-1989. His research interests are anchored in social psychology, statistics, and survey methodology. A member of the Committee on National Statistics of the NRC from 1987-1988, Norman Bradburn served as chair of the committee from 1993-1998. From 1992-1994 he was chair of the Panel to Evaluate Alternative Census Methods for Census 2000 and Beyond, another committee of the NRC. During 1988 to 1992, he chaired the NRC's Board on International Comparative Studies in Education. A survey methodologist, Norman Bradburn is past president of the American Association of Public Opinion Research. He is a member of the American Academy of Arts and Sciences and is a fellow of the American Statistical Association. He has written extensively on cognitive aspects of survey response, asking sensitive questions, and recall errors in surveys. He is the author, with Seymour Sudman, of several books on survey methodology. In 1995, with co-authors Seymour Sudman and Norbert Schwarz, he published his sixth book, *Thinking About Answers: The Application of Cognitive Processes to Survey Methodology*.

Glen Cain is Emeritus Professor of the economics department and a research associate of the Institute for Research on Poverty at the University of Wisconsin. His field is labor economics, and his current research is on Wisconsin's welfare program, on the relation between the macro-economic performance of the United States economy and poverty, and on

long-run trends in time spent at work and the composition of the labor force in the United States. He has participated in the analysis of controlled field experiments in income-maintenance programs and has conducted evaluation studies and written on evaluation methods of non-experimental training and educational programs. His B.A. is from Lake Forest College (1955), M.A. from the University of California at Berkeley (1957) and Ph.D. from the University of Chicago (1964).

Susan Chipman manages the Cognitive Science program at the U.S. Office of Naval Research, as well as more applied programs in advanced training technology. Previously, she was Assistant Director of the National Institute of Education, where she was responsible for managing research programs in mathematics education, cognitive development, computers and education, and social influences on learning and development. For a number of years, she served as an advisor to the James S. McDonnell Foundation's education research program. Prior to becoming a research manager, her personal research focused on visual pattern perception and its development, and she has also written extensively on the participation of women and minorities in mathematics, science and technology. Books she has edited are *Thinking and Learning Skills*, *Women and Mathematics: Balancing the Equation*, *Knowledge Acquisition*, *Cognitively Diagnostic Assessment* and *Cognitive Task Analysis*. She received an AB in Mathematics, MBA, and AM and Ph.D. in Experimental Psychology from Harvard University and is a Fellow of both the American Psychological Association and the American Psychological Society.

Christopher T. Cross is President and Chief Executive Officer of the Council for Basic Education (CBE). The Council, established in 1956, is an independent critical voice for education reform, advocating a curriculum strong in the liberal arts for all children in the nation's public elementary and secondary schools. Before joining CBE, Mr. Cross served as Director of the Education Initiative of The Business Roundtable and as Assistant Secretary for Educational Research and Improvement, U.S. Department of Education. Mr. Cross chairs an NRC Panel on Minority Representation in Special Education and the National Council for Education and Human Development at George Washington University. He chairs the board of the Center for Education Policy and is a member of the board of directors of the American Institutes for Research. He serves on the board of trustees of Whittier College; the board of visitors of the College of Education, University of Maryland; the Danforth Foundation's Policymakers' Program Advisory Board; and the Board of International Comparative Studies in Education for the NRC. From 1994-1997, Mr. Cross served as president of the Maryland State Board of Education. He was a member of the National Education Commission on Time and Learning. He has written extensively in the education and public policy areas and has been published in numerous scholarly and technical publications, including *Education Week*, *Kappan*, *The College Board Review*, *The American School Board Journal*, *The Washington Post*, *The Baltimore Sun*, and the *Los Angeles Times*.

Michael J. Feuer is the Director of the Center for Education at the NRC. He was formerly the Director of the Board on Testing and Assessment in the NRC's Commission on Behavioral and Social Sciences and Education. Before joining the NRC, Dr. Feuer served as senior analyst and study director at the Office of Technology Assessment (OTA), where he worked on a variety of education and human resources projects, including educational

technology, vocational education, performance standards, and educational testing. He holds a Ph.D. in Public Policy from the University of Pennsylvania, where his research focused on mathematical modeling and human resource planning in organizations. He went on to a faculty position at Drexel University, where he taught courses in economics, public policy, and technology management. While at Drexel he published a series of articles on the economics of firm-sponsored education and training, which suggested variations to conventional human capital theory. Though granted early tenure at Drexel, he chose to move to Washington in 1986 to work at OTA on the interaction between social and cognitive sciences and education, training, and human capital.

Larry V. Hedges is the Stella M. Rowley Professor of Education, Psychology, Public Policy Studies, and Sociology at the University of Chicago. His primary research interests are the application of statistical methods to problems in education, the social sciences, and policy studies, particularly the combination of results of replicated empirical research studies (meta-analysis), statistical models in cognitive science, and educational and psychological measurement. He has served as chairman of the Department of Education at the University of Chicago. He is Editor of the *Journal of Educational and Behavioral Statistics* and was Quantitative Methods Editor of *Psychological Bulletin*, and currently serves on the editorial boards of *Psychological Methods*, the *American Journal of Sociology*, and the *Review of Educational Research*. He is a member of the National Academy of Education, a Fellow of the American Statistical Association and the American Psychological Association, an elected member of the Society for Multivariate Experimental Psychology, and was a visiting fellow of the Russell Sage Foundation. He is currently a member of the U.S. Advisory Committee on Education Statistics and has served on numerous professional boards and panels including several National Research Council committees. His recent books include *Statistical Methods for Meta-analysis* (with Ingram Olkin) and *The Handbook of Research Synthesis* (with Harris Cooper). In addition, he has published numerous research articles in psychology, the social sciences, and statistics.

Jeremy Kilpatrick is Regents Professor of Mathematics Education at the University of Georgia. Before joining the faculty at Georgia in 1975, he taught at Teachers College, Columbia University. He holds an A.B. and M.A. from the University of California at Berkeley, an M.S. and a Ph.D. from Stanford University, and an honorary doctorate from the University of Gothenburg in Sweden. In addition to receiving Fulbright awards for work in New Zealand, Spain, Colombia, and Sweden, he has taught courses in mathematics education at several European and Latin American universities. He was a charter member of the NRC's Mathematical Sciences Education Board and served two terms as Vice President of the International Commission on Mathematical Instruction. A former editor of the *Journal for Research in Mathematics Education*, he recently co-edited a two-volume publication on mathematics education as a research domain. For the NRC, he chaired the Study Group on Guidelines for Mathematics Assessment and, more recently, the Mathematics Learning Study, whose report *Adding It Up* is being published by the National Academy Press.

David Klahr received his B.S. from MIT in Electrical Engineering, and his Ph.D. from Carnegie Mellon's School of Industrial Administration in Organizations and Social Behavior. From 1967-1969, he was an Assistant Professor at the University of Chicago. He returned to

Carnegie Mellon in 1969, and became Professor of Psychology in 1976. He served as Department Head from 1983 to 1993. In addition to nearly 100 journal articles, Klahr is the author of two books: *Cognitive Development: An Information Processing View* (Erlbaum, 1976, with J. G. Wallace) and *Exploring Science: The Cognition and Development of Discovery Processes* (MIT Press, 2000) and editor or co-editor of four volumes: *Cognition & Instruction* (Erlbaum, 1976), *Production System Models of Learning and Development* (MIT Press, 1987, with P. Langley and R. Neches), *Complex Information Processing: The impact of Herbert A. Simon* (Erlbaum, 1989, with K. Kotovsky), and *Cognition & Instruction: 25 Years of Progress* (Erlbaum, 2001, with Sharon Carver). His recent research on the development of problem-solving and scientific reasoning skills is reported in *Cognitive Psychology, Cognitive Science, Cognition & Instruction,* and *Child Development*. Dr. Klahr is a Fellow of the American Psychological Association, a Charter Fellow of the American Psychological Society, a member of the Society for Research in Child Development, the Cognitive Science Society, and on the Governing Board of the Cognitive Development Society. He has served on the editorial boards of several cognitive science journals and on scientific review panels for the McDonnell Foundation, the NSF, and the NIH. He recently completed service on the NRC's Committee on the Foundations of Assessment.

Sharon Lewis is the Director of Research for the Council of the Great City Schools. As director of research, Ms. Lewis is responsible for developing and maintaining a research program that articulates the status, needs, attributes, operation, and challenges of urban public schools and the children whom they serve. Mrs. Lewis previously served as assistant superintendent in the Department of Research, Development and Coordination for Detroit Public Schools where she was responsible for all testing, research, and evaluation conducted within the school district. Additionally, Mrs. Lewis is the former director of the Office of Research, Evaluation and Testing for Detroit Public Schools. Mrs. Lewis has served as an international educational consultant to the U.S. Department of Defense Dependents Schools, Germany Region, and was a State of Michigan delegate to the Soviet Union and the People's Republic of China.

G. Reid Lyon is a research psychologist and the Chief of the Child Development and Behavior Branch within the National Institute of Child Health and Human Development (NICHD) at the NIH. He is responsible for the direction, development and management of research programs in developmental psychology, cognitive neuroscience, behavioral pediatrics, reading, and human learning and learning disorders. Before joining the NIH on a full-time basis in 1991, Dr. Lyon served on the faculties of Northwestern University (Communication Science and Disorders/ Neuroscience-1980-1983) and the University of Vermont (Neurology-1983-1991). He was a member of the Maternal and Child Health Scientific Peer Review Group at NICHD/NIH from 1987 to 1991. Dr. Lyon's research program was supported, in part, by grants from the NIH and the U.S. Department of Education. Dr. Lyon received his Ph.D. from the University of New Mexico (1978) with a dual concentration in psychology and developmental disabilities. He completed a Fellowship in developmental neuroscience at the University of New Mexico Medical Center. He has taught children with learning disabilities, served as a third grade classroom teacher, and served as a school psychologist for 12 years in the public schools. Dr. Lyon has authored, co-authored, and edited over 100 journal articles, books, and book chapters addressing learning differences and disabilities in children. He is currently responsible for translating

NIH scientific discoveries relevant to the health and education of children to the White House, the United States Congress, and other governmental agencies. He also currently serves as an advisor to President George W. Bush on child development and education research and policies.

C. Kent McGuire is Senior Vice President at the Manpower Demonstration Research Corporation (MDRC). At MDRC he is dividing his time between developing and managing research projects focused on school reform and education policy and serving as the director of MDRC's Department on Education, Children and Youth. He most recently served as Assistant Secretary of Education, with responsibility for the Office of Education Research and Improvement. There he was responsible for managing a wide range of federal grants and contracts administered through eight different operating units within the agency. Previous positions include Education Program Officer at the Pew Charitable Trusts, Education Program Director at the Lilly Endowment, Inc and Senior Policy Analyst and Director of the School Finance Center at the Education Commission of the States. He received in Ph.D. in Public Administration in 1991 from the University of Colorado.

Robert Mislevy is a Professor in the Department of Educational Measurement, Statistics, and Evaluation at the University of Maryland, College Park. Before coming to the University of Maryland, he was a Distinguished Research Scientist in the Division of Statistics and Psychometrics Research at Educational Testing Service. He earned his Ph.D. in Methodology of Behavioral Research at the University of Chicago in 1981. Dr. Mislevy's research centers on applying developments in statistical methodology and cognitive science to practical problems in educational and psychological measurement, and he has published some sixty papers, book chapters, and monographs on these topics. His work includes a multiple-imputation approach for integrating sampling and test-theoretic models in the National Assessment of Educational Progress (NAEP), a Bayesian inference network for updating the student model in an intelligent tutoring system, and a framework for monitoring and improving portfolio assessment evaluation. He was awarded the American Educational Research Association's Raymond B. Cattell Early Career Award for Programmatic Research, and three times has received the National Council of Measurement in Education's Triennial Award for Technical Contributions to Educational Measurement. He has served as president of the Psychometric Society and as a member of National Research Council's committees on assessment instruction, and cognitive psychology.

William Morrill is a Senior Fellow at Caliber Associates of Fairfax, VA. He received his B.A. from Wesleyan University and his M.P.A. from the Maxwell School, Syracuse University. After many years of Federal service including work at the Office of Management and Budget and as Assistant Secretary for Planning and Evaluation at the Department of Health, Education and Welfare, he has been a researcher and institutional leader at two of the Mathematica companies. His recent work includes a study of the national educational research, development and dissemination system and a just completed evaluation of the Congressionally mandated expert panel process for selection of promising and exemplary educational programs, both done for the National Educational Research Policy and Priorities Board. He has substantial experience in the organization, planning and assessment of R&D programs and evaluation activities.

William Quinn is Senior Program Associate at the North Central Regional Educational Laboratory, Naperville, Illinois. He received his B.S. and M.Ed. from Brigham Young University, and Ed.D. from Western Michigan University. His work has focused extensively on conducting educational evaluations at the school, district, and state levels. He has conducted over 100 evaluation studies at the school, district, state, and national levels. He has had extensive experience evaluating technology use in public education, university, and private settings. Some of his recent evaluation studies include a four-year study of technology use in Indiana elementary schools and homes, an evaluation of Chicago school reform, an assessment of how well Iowa's preschool programs prepare children for kindergarten and evaluations of technology use for the state of Virginia and for the Miami-Dade School District. He has published research and evaluation reports on technology use in instruction, elementary literacy and math achievement, cost-effectiveness of training and professional development, assessment of year-round schooling, and teacher evaluation systems.

Diane Ravitch is a distinguished visiting fellow at the Hoover Institution and a member of the Koret Task Force on K–12 Education. Ravitch is a senior fellow at the Brookings Institution, where she holds the Brown Chair in Education Policy. Additionally, she is a research professor at New York University and a member of the board of the New America Foundation. Since 1997, Ravitch has been a member of the National Assessment Governing Board. She is also a member of the American Academy of Arts and Sciences, the National Academy of Education, and the Society of American Historians. During the Bush administration, Ravitch served as an assistant secretary for educational research and improvement and as a counselor to the U.S. Department of Education. She is a former professor of history and education at Columbia University's Teachers College and a former adviser to Poland's Ministry of Education. Ravitch is the editor of many publications, including the annual Brookings Papers on Education Policy. She edited *The Schools We Deserve, Debating the Future of American Education,* and *The American Reader*. She has many books to her credit including *Left Back: A Century of Failed School Reforms*; *National Standards in American Education: A Citizen's Guide*; *What Do Our 17-Year Olds Know?* (with Hoover Distinguished Visiting Fellow and Koret Task Force member Chester Finn Jr.); *The Great School Wars: New York City, 1805–1973*; and *The Troubled Crusade: American Education, 1945–1980*. Her publications have been translated into many languages. Her articles have appeared in the *Wall Street Journal*, the *Washington Post*, the *New York Times*, and the *Brookings Review*. Ravitch, a historian of education, has lectured on democracy and civic education throughout the world.

Sally Rockey has spent her career in the area of research administration. She received her Ph.D. in Entomology (1985) from The Ohio State University and held a post doctoral appointment at the University of Wisconsin. In 1986 she joined the USDA Competitive Research Grants Office of Cooperative State Research Service (CSRS) as program director for two entomological programs. In 1991 she became Division Director for the Plants Division of the National Research Initiative Competitive Grants Program (NRI), CSRS, USDA. In 1996 she assumed her current position of Deputy Administrator for the Competitive Research Grants and Award Management Unit of the Cooperative State

Research, Education, and Extension Service (CSREES) which is the extramural research, education and education arm of the USDA. Dr. Rockey oversees the competitive portion of the research portfolio within CSREES as well as oversees the financial and administrative management of all CSREES grants and agreements. As research administration and science policy have been central to her career, Dr. Rockey has given over 100 presentations on agricultural research, grantsmanship, the competitive peer review process, and ethics in the Federal grants process. She is active on a number of Federal intergovernmental committees related to science and research and is the USDA representative to many science-related groups outside the Federal government. She actively participates in the science education of young children by giving presentations on insects to local elementary schools where she is known as the "Bug Doctor."

Steven M. Ross received his doctorate in educational psychology from the Pennsylvania State University. He a currently a professor and research director in the Center for Research in Educational Policy at the University of Memphis which he joined in 1974, and a noted lecturer on school programs and educational evaluation. Dr. Ross is the author of six textbooks and over 115 journal articles in the areas of at-risk learners, educational reform, educational technology, computer-based instruction, and individualized instruction. He is the editor of the research section of *Educational Technology Research and Development* and a member of the editorial board for two other professional journals. In the 1993, he was the first faculty recipient of the University of Memphis Eminent Faculty Award for teaching, research, and service. He recently testified on school restructuring research before the U.S. House of Representatives Subcommittee on Early Childhood, Youth, and Families, and was an invited panelist at Secretary of Education Riley's national town meeting on educational reform. Other recent work has been with value-added assessment in program evaluation, in collaboration with Dr. William Sanders. In 2001, Dr. Ross was appointed as the first recipient of the Lillian and Morrie Moss Chair of Excellence in Urban Education at the University of Memphis.

Nancy Butler Songer is an Associate Professor of Science Education and Educational Technology, at the University of Michigan. She received her Ph.D. in Science Education, University of California at Berkeley. Professor Songer's field of expertise is explorations of the educational potential and realities of innovative technologies for reform-based science education in urban settings, elementary and middle school science, and the development of learning environments which are sensitive to diversity and gender issues. Recent awards include The Secretary's National Conference on Educational Technology 2000, Smithsonian Technology Award 2000, and National Science Foundation Presidential Faculty-Fellow 1995-2000.

Judith Sunley is the interim Assistant Director for the Directorate for Education and Human Resources at the NSF. Prior to her appointment to this position in August 1999, Dr. Sunley served for five years as Assistant to the Director for Science Policy and Planning. In this capacity, she played a lead role in NSF's budgeting, planning, and program implementation. Dr. Sunley coordinated final stages in the development of NSF's 1995 strategic plan, *NSF in a Changing World*, and Foundation implementation of the 1993 Government Performance and Results Act. She served as co-chair of an interagency working group with the

Department of Education charged with developing an action strategy for using key federal resources to assist states and local school systems in improving student achievement in mathematics and science. She continued her involvement in education issues as part of the working group coordinating the Interagency Education Research Initiative, a partnership of NSF, the Department of Education, and the NIH. Dr. Sunley joined the National Science Foundation in 1980. Prior to serving as Assistant to the Director, she was the Executive Officer for Mathematics and Physical Sciences. She also served as Associate Program Director, Deputy Division Director, and Division Director in the Mathematical Sciences Division. Before coming to NSF, Dr. Sunley held positions as faculty member, Department Chair, and Associate Dean at American University. She received her Ph.D. from the University of Maryland and her M.S. and B.S. degrees from the University of Michigan, all in mathematics.

Richard Suzman is the Associate Director for the Behavioral and Social Research Program at the National Institute on Aging (NIA), NIH. He has served previously as Chief of Demography and Population Epidemiology at NIA, where he developed and directed the program that funds research and training in demography, epidemiology, and the economics of aging. He is also Director of the Office of the Demography of Aging, the focal point for demographic statistics and research within NIA and across other Federal and international agencies. Dr. Suzman was Staff Director of the Federal Forum on Aging-Related Statistics, a coordinating organization made up of over 35 Federal agencies and jointly chaired by the National Center for Health Statistics, Bureau of the Census, and NIA. He was instrumental in developing the Health and Retirement Study (HRS) and its companion survey of Asset and Health Dynamics Among the Oldest-Old (AHEAD), as well as several other national longitudinal surveys on aging. Formerly on the faculty of the University of California, San Francisco, Medical School, Dr. Suzman has edited several volumes including, the *Oldest Old* and *Forecasting the Health of Elderly Populations*. After attending the University of the Witwatersrand, he received his undergraduate and graduate degrees from Harvard University, and a Diploma of Social Anthropology from Oxford University. He was a Post Doctoral Fellow at Stanford University, where he also served briefly on the faculty.

Peter Tillers is Professor of Law at Benjamin N. Cardozo School of Law, Yeshiva University, and he is currently Senior Research Associate in Law at Yale Law School. He specializes in the law of evidence, the process of fact investigation, and the logic of inductive and abductive inference. He is a reviser of Wigmore's classic treatise on the law of evidence and he has published a variety of articles on evidence, inference, and investigation. He is former chairman and secretary of the evidence section of the Association of American Law Schools. He was a Fellow of Law and Humanities at Harvard University and a Senior Max Rheinstein Fellow at the University of Munich. He will be Visiting Professor of Law at Harvard Law School in the spring of 2002. Tillers' current research focuses on the possible uses of computer technology for marshalling evidence in dynamic forensic processes.

Maris Vinovskis is the Bentley Professor of History, a Senior Research Scientist at the Center for Political Studies in the Institute for Social Research, and a member of the Faculty at the Gerald Ford School of Public Policy at the University of Michigan. He received his Ph.D. in American History from Harvard University and taught at the University of

Wisconsin from 1972-1974. He was been at the University of Michigan for 26 years and has served as a chair of the History Department. His areas of specialization in American history are demographic history, education history, family history, and policy history. Among the honors he has received are a Guggenheim Foundation fellowship as well as a Distinguished Faculty Award from the University of Michigan. He has been elected as the President of the History of Education Society as well as a member of the National Academy of Education. He has authored or co-authored eight books and edited or co-edited another eight volumes. His most recent book, *History and Educational Policymaking* was published by Yale University Press and he has a forthcoming book, *Revitalizing Federal Education Research*, which the University of Michigan Press will be publishing in 2001. Dr. Vinovskis has frequently worked with the federal government including serving as the Deputy Staff Director of the U.S. House Select Committee on Population (1978), consultant to the U.S. Office of Family Planning Programs (1983-1985), and consultant to the U.S. Office of Adolescent Pregnancy Programs (1981-1983). Vinovskis was the Research Adviser to the Assistant Secretary of OERI in both the Bush and Clinton administrations in 1992 and 1993 and then served as a consultant to OERI for two years. He was a member of the Independent Review Panel for the U.S. Department of Education and has testified several times in recent years before the House and Senate on federal education research and compensatory education policies.

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